AnExtensive Review onChannel Estimation in Wireless OFDM Systems

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Abstract- In various wireless conditions, signals skip off numerous obstacles, for example, mountains, structures, trees, and so on as they spread among transmitters and receivers. The resultant signal at the receiver antenna is, hence, regularly the total of the attenuated transmitted signal and one or more delayed variants of the transmitted signal. The received signal likewise experiences intersymbol interference which degrades the nature of signal to a certain extent.However, MIMO-OFDM systems are designed to exploit the multi-path properties in wireless communications and are fit for improving transmission rate, range and reliability all the while. MIMO-OFDM attracts a good deal of research and commercial interest because of the perceived benefits, and has been adopted in many wireless standards. Tis work presnts an extensive survey of literature based on recent work on Channel estimation in MIMO OFDM.

Keywords- MIMO-OFDM, Channel Estimation, Fading, Wireless Communication,Channel Fading.

I. INTRODUCTION

Wireless communication has become one of the fastest growing industries during the last few decades. Over 2 billion users are involved and make it one of largest research and business fields. With the development of mobile devices, many technical challenges have arisen such as video streaming, online-gaming and real-time video meeting. Hence, the 3rd and 4th generations of cellular systems such as WiMAX, LTE, and LTE-Advanced have been deeply studied and deployed in many developing and developed countries. However, a higher quality of service is required for the current systems, that is, higher data rate, higher spectral efficiency and more reliable link. These features must be provided with lower cost (reduced size of equipment and less energy consumption etc.).

For instance, MIMO-OFDM has been employed in LTE-Advanced. A tradeoff between complexity and performance may be required in the sense that the suboptimal detection methods have lower complexity at the expense of poorer performance compared to ML receivers. In addition, hundreds of subcarriers have been exploited in such systems, which make the receiver design more complicated than narrow-band MIMO systems. Also, the wireless channels results in the distortion and superposition of the transmitted signals from multiple transmit antennas. Hence, lower-complexity and more robust channel estimation and detection techniques are critical to wireless communication systems.

To obtain a higher data rate, MIMO techniques are widely used in most current wire- less communication systems. There are three significant advantages of multi- antenna systems: (1) energy efficiency. The signal to noise ratio (SNR) is improved; (2) diversity gain. The fading effect can be compensated for the replica of signals over different uncorrelated channels; (3) multiplexing gain. The data rate can be increased by transmitting independent data streams through multiple transmit antennas. The the- oretical research on MIMO was pioneered which describes that the capacity for single user communication in fading channels can significantly increases using multiple antennas. Although the theoretical analysis on the capacity of MIMO channels has been established, the more practical algorithms to achieve the capacity are still waiting for further study. It shows that an enhanced spectral efficiency 20 bits/Hz/s can be achieved. The advantage of multiple antennas techniques is to transmit or receive several signals carrying same information to combat with the faded channels. Hence, the fading can be beneficial in multi-antenna systems rather than detrimental in the single- antenna systems.

Although the performance of SD is significantly improved, there is still a large gap between the achievable capacity of SD and the capacity of MIMO channels. Iterative detection and decoding (IDD) has attracted significant attention within the last 20 years after Turbo Codes appeared, because of the near-capacity performance. OFDM transmits a large number of narrowband carriers, closely spaced in the frequency domain. In order to avoid a large number of modulators and filters at the transmitter and complementary filters and demodulators at the receiver, it is desirable to be able to use modern digital signal processing techniques, such as fast Fourier transform (FFT).

Basically MIMO stands for multiple inputs multiple outputs. It means multiple antennas on both the side of communication system which is transmitter and receiver.

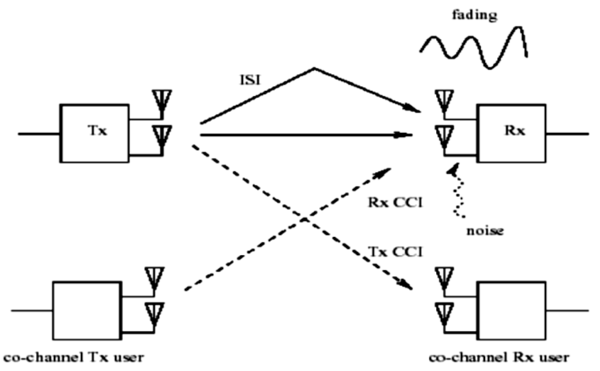

Figure: 1.1 MIMO Systems.

MIMO systems which used at both transmitter and receiver side are capable to reduce all these limitation in a certain extend. Due to gain of spatial multiplexing the communication channel capacity improves. The increased capacity does not take more power as well as bandwidth.

While by the diversity gain can see the improvement in reliability. By the antenna array system the output signal to noise ratio is more than N times input signal while N stands for noise power. So it can see that by these and by many more parameter increases many limitation of wireless communication.

II. SYSTEM MODEL

Figure 2.1 shows a simplified model of a digital communication system. Recommended textbooks on this subject. The objective of the communication system is to connect digital information (a sequence of binary information digits) over a noisy channel at as high bit rates as attainable. The data to be transmitted could origin from any source of information. In case the information is an analog signal, such as speech, then an A/D converter must precede the transmitter.

The source encoder outputs data that are to be transmitted over the channel at a certain information bit rate, R_b. As a measure of performance define the bit error probability, P_b, as the probability that at the destination a bit is incorrectly received. As it will see later, the channel may interfere with the communication, thus increasing the bit error probability.

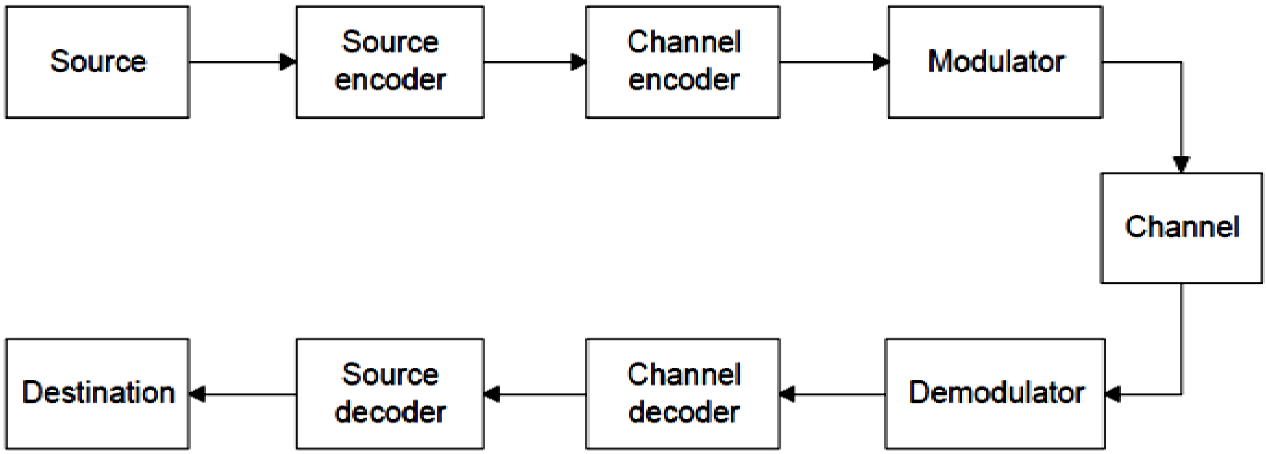

Figure: 2.1 Model of digital communication system.

a. Source Coding

Most data contains redundancy, which makes it possible to compress the data. This is done by the source encoder and minimizes the amount of bits transmitted over the channel. At the receiver the source decoder unloads the data to either an precise replica of the source (lossless data compression) or a distorted version (lossy data compression). If the received sequence does not have to be an exact copy of the transmitted stream then the degree of compression can be increased.

b. Channel coding

In order to reduce the bit error probability the channel encoder adds redundancy (extra control bits) to the bit sequence in a controlled way. When an error appears in the bit stream the extra information may be used by the channel decoder, to detect, and possibly correct, the error. The redundancy added is depending on the amount of correction needed but is also tuned to the characteristics of the channel. There are two coding techniques which are used mostly are

1. Block codes
2. Convolutional codes.

c. Modulator

The modulator produces an information-carrying signal, propagating over the channel. At this stage the data is converted from a stream of bits into an analog signal that the channel can handle. The modulator has a set of analog waveforms at its disposal and maps a certain waveform to a binary digit or a sequence of digits. At the receiver, the demodulator attempts to detect which waveform was transmitted, and convert the analog information back to an order of bits. Numerous modulation techniques exists, e.g., spread-spectrum, OFDM (Orthogonal Frequency Division Multiplex), GMSK (Gaussian Minimum Shift Keying), QAM (Quadrature Amplitude Modulation), FSK (Frequency Shift Keying) and PSK (Phase Shift Keying).

d. Channel

The channel might be any physical medium, such as coaxial cable, air, water or telephone wires. It is important to know the characteristics of the channel, such as the attenuation and the noise level, because these parameters directly affect the performance of the communication system.

d. Bandwidth

The frequency content of the information-carrying signal is of great importance. The frequency interval used by the communication system is called bandwidth, W. For a precise communication method, the bandwidth needed is proportional to the bit rate. Thus a higher bit rate needs a larger bandwidth for a fixed method. If the bandwidth is doubled then the bit rate is also doubled. In today's environment bandwidth is a limited and precious resource and the bandwidth is often constrained to a certain small interval. This puts a restriction on the communication system to communicate within the assigned bandwidth.

e. Diversity

To reduce the error probability of severe channels, diversity techniques may be used. Examples are time diversity and frequency diversity. In time diversity the same information is transmitted more than once at abundant different time instants. If the channel is bad at some time instant the information might pass through at some other time when the channel is good (or better). This is especially useful on time-varying channels. Frequency diversity transmits the same information at different locations in the frequency domain. It may be compared to having 2 antennas sending at completely different frequencies, if one in all them fail the opposite may work.

III. LITERATURE SURVEY

SR. NO.	TITLE	AUTHOR	YEAR	APPROACH
1	Channel Estimation in MIMO - OFDM Systems based on a new adaptive greedy algorithm,	Y. Huang, Y. He, Q. Luo, L. Shi and Y. Wu,	2018	Reported a new adaptive matching pursuit (NAMP) algorithm and the evaluation prototype based on LTE-Advanced wireless channel model
2	Doppler Spread Estimation in MIMO Frequency-Selective Fading Channels	M. Mohammadkarimi, E. Karami, O. A. Dobre and M. Z. Win	2018	Derived the data-aided (DA) and non-data-aided (NDA) Cramér-Rao lower bounds (CRLBs) and maximum likelihood estimators (MLEs) for the MDS in multiple-input multiple-output (MIMO) frequency-selective fading channel
3	A Semi-Blind Channel Estimation Algorithm for Massive MIMO Systems	K. Mawatwal, D. Sen and R. Roy,	2017	Reported a semi-blind iterative space-alternating generalized expectation maximization (SAGE)-based channel estimator for massive MIMO systems
4	Compressive sensing based time-varying channel estimation for millimeter wave systems,	Q. Qin, L. Gui, B. Gong, J. Xiong and X. Zhang,	2017	Reported an efficient sparse channel estimation scheme based on compressive sensing (CS) theory. Specifically, considering that the angles of arrival/departure (AoAs/AoDs) vary more slowly than the path gains
5	Compressive sensing based channel estimation for scattered pilot OFDM Systems over doubly-selective Rician channel,	Tianjun Liu, Kaili Zheng and Ping Wang,	2016	A typical high-speed train (HST) communication system based on orthogonal frequency division multiplexing (OFDM) is considered and the wireless channel is estimated in utilizing the sparsity of the channel
6	Design Criteria for FIR-Based Echo Cancellers,	F. Zabini, G. Pasolini and O. Andrisano	2016	Considered a realistic OCR setup and analytically derive proper design criteria for echo-cancellers, showing the role of system parameters and implementation aspects on their performance
7	Channel estimation for MIMO-OFDM systems,	S. Manzoor, A. S. Bamuhaisoon and A. N. Alifa	2015	A Simulink model is developed for performing channel estimation, assuming that the STBC is used

Y. Huang, Y. He, Q. Luo, L. Shi and Y. Wu, [1] Channel estimation methods based on Compressed Sensing (CS) can be used to obtain channel state information of MIMO-OFDM system effectively. This examination reported new adaptive matching pursuit (NAMP) algorithm and the evaluation prototype based on LTE-Advanced wireless channel model. First, NAMP does not need the priori-knowledge of the sparsity level. Second, the fixed step size is determined in order to improve the efficiency of signal reconstruction. Third, a Singular Entropy order determination mechanism is employed to prevent the less relevant atoms from being introduced. Finally, Simulation results are discussed in detail, which demonstrate that the proposed method expenses smaller computational complexity, especially achieves more stable performance.

M. Mohammadkarimi, E. Karami, O. A. Dobre and M. Z. Win, [2] One of the main challenges in high-speed mobile communications is the presence of large Doppler spreads. Thus, accurate estimation of maximum Doppler spread (MDS) plays an important role in improving the performance of the communication link. In this exploration, derive the data-aided (DA) and non-data-aided (NDA) Cramér-Rao lower bounds (CRLBs) and maximum likelihood estimators (MLEs) for the MDS in multiple-input multiple-output (MIMO) frequency-selective fading channel. Moreover, a low-complexity NDA-moment-based estimator (MBE) is proposed. The proposed NDA-MBE relies on the second- and fourth-order moments of the received signal, which are employed to estimate the normalized squared autocorrelation function of the fading channel. Then, the problem of MDS estimation is formulated as a non-linear regression problem, and the least-squares curve-fitting optimization technique is applied to determine the estimate of the MDS. This is the first time in the literature, when DA- and NDA-MDS estimation is investigated for MIMO frequency-selective fading channel. Simulation results show that there is no significant performance gap between the derived NDA-MLE and NDA-CRLB, even when the observation window is relatively small. Furthermore, the significant reduced-complexity in the NDA-MBE leads to low root-mean-square error over a wide range of MDSs, when the observation window is selected large enough.

K. Mawatwal, D. Sen and R. Roy, [3] In this work, reported a semi-blind iterative space-alternating generalized expectation maximization (SAGE)-based channel estimator for massive MIMO systems. The method updates the pilot-based minimum mean square error (MMSE) estimate iteratively with the help of the SAGE algorithm. Pilot-based estimators require additional pilot symbols for enhancing accuracy, whereas the proposed estimator uses data symbols. Several of the existing estimators assume complete information on large scale fading coefficients of the interfering cells which requires heavy overhead. However, the proposed estimator solves this problem by an estimate obtained from the received samples. Further, show that the proposed estimator converges almost in one iteration, and achieves appreciable improvement over the existing pilot-based and data-aided estimators in a pilot contaminated scenario.

Q. Qin, L. Gui, B. Gong, J. Xiong and X. Zhang, [4] Channel estimation for millimeter wave (mmWave) systems over time-varying channels is a challenging problem, since a large number of channel coefficients need to be estimated. In this examination, by exploiting the sparsity of mmWave channel in the angular domain, reported an efficient sparse channel estimation scheme based on compressive sensing (CS) theory. Specifically, considering that the angles of arrival/departure (AoAs/AoDs) vary more slowly than the path gains, formulate the channel estimation into a block-sparse signal recovery problem, and then propose a novel greedy algorithm consistent with the block structure to estimate AoAs/AoDs. Based on the estimated angles, design optimal training hybrid precoders and combiners to maximize array gains, followed by estimating the path gains utilizing the least square (LS) method. The simulation results demonstrate that our proposed scheme performs better than the existing mmWave channel estimators in both estimation accuracy and spectral efficiency over time-invariant channels, and further verify that our proposed scheme is suitable for time-varying channels.

Tianjun Liu, Kaili Zheng and Ping Wang, [5] In this examination, a typical high-speed train (HST) communication system based on orthogonal frequency division multiplexing (OFDM) is considered and the wireless channel is estimated in utilizing the sparsity of the channel. For the complex-exponential basis expansion model (CE-BEM) based channel model, the time-frequency selectivity channel can be estimated more accurately which base the compressive sensing (CS) theory than conventional channel estimation methods. In this examination, the sparsity of Rician channel at each subcarrier in OFDM system is proved. And compressive sensing based channel estimation algorithm for scattered pilot OFDM Systems over doubly-selective Rician channel is proposed. Simulation results show that the proposed channel estimation algorithm is insensitivity to mobile speed and can achieve better channel estimation performance in terms of mean square error and bit error rate compared with the existing algorithms.

F. Zabini, G. Pasolini and O. Andrisano,[6] The most relevant impairment experienced by on-channel repeaters (OCRs) in single frequency networks scenarios is the presence of a coupling-channel between the transmitting and receiving antennas, that generates unwanted echoes. This phenomenon causes a degradation of the repeated signal and, above all, could lead to the instability of OCRs, owing to the positive feedback that could result. For this reason, OCRs are usually equipped with echo canceller units, aimed at removing the coupling contributions. In this exploration work, consider a realistic OCR setup and analytically derive proper design criteria for echo-cancellers, showing the role of system parameters and implementation aspects on their performance. Here, in particular, investigate the joint effect of the estimation noise and the finite precision arithmetic of digital systems, the system sensitivity to different design parameters and the relation between the echo-cancelling performance and the probability of instability.

S. Manzoor, A. S. Bamuhaisoon and A. N. Alifa,[7] Channel estimation is a very important process in the operation of MIMO-OFDM systems, as it is vital for accurately estimating the Channel Impulse Response (CIR) of the channel under various conditions. As such, it is useful to have a Matlab®/ Simulink to model the behavior of the channel estimation process in a MIMO-OFDM system, in order to study the error rate of the system under different modulation and SNR conditions. As one of the most common transmitter diversity schemes used in MIMO-OFDM systems is Alamouti's Space Time Block Code (STBC), a Simulink model is developed for performing channel estimation, assuming that the STBC is used. The model will then generate graphs of error rates vs SNR for different modulation schemes. The results show great improvement in Bit Error Rate (BER) by utilizing a Reed-Solomon Forward Error Correction code (RS-FEC) method.

IV. PROBLEM STATEMENT

MIMO-OFDM systems are designed to take advantage of the multi-path properties in wireless communications and are capable of improving transmission rate, range and reliability simultaneously. MIMO-OFDM attracts a good deal of research and commercial interest because of the perceived benefits, and has been adopted in many wireless standards such as IEEE 802.1 In, IEEE 802.16e. Such systems are also potential candidates for fourth-generation (4G) systems. However, practical problems still exist in implementing MIMO-OFDM, for example, in the estimation of channel state information (CS1). This examination studies the issues of MIMO, OFDM and the relevant techniques of MIMO-OFDM, and focuses on proposing a practical, low complexity and accurate channel estimation method for such systems.

V. CONCLUSION

This examinationwork presents an extensive survey of literature based on recent work on Multi-input and multi-output (MIMO) and orthogonal frequency division multiplexing (OFDM).It has pulled in critical consideration, and end up promising methods for high data rate wireless communication systems. They have been generally contemplated and utilized for 4G systems, for example, WiFi, DVB-T, WiMAX and LTE-A.Channel estimation is a challenging issue in wireless systems since mobile radio channels are profoundly powerful. To maintain a strategic distance from channel estimation, one can adopt a differential modulation method instead of rational modulation. Channel estimation for OFDM systems in moderate fading channels has been broadly examined.

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